ESTIMATING EGGS

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enlighten us on the teaching and learning of mass estimation.

Mass is one of the three fundamental measurements — the others being length and time. However, estimation of mass is little taught and assessed in primary schools. This article briefly explores the reasons for this in terms of culture, practice and the difficulty of assessing estimation of mass. A fun activity using the differences between a set of nested eggs is outlined in this article. Use of this activity may help to promote the exploration of mass estimation concepts as well as the assessment of mass in a classroom environment. Students' general misconceptions in relation to mass, their limited formal and informal experiences with estimating mass as well as the infrequent assessment of estimation of mass concepts are the springboards for this activity.

What is mass?

Mass is a measure of the quantity of matter present in an object. It can be seen as one of the measurable criteria by which we can differentiate objects.

At the primary school level, children can explore, measure and experience mass on Earth, in air and in constant gravity. Within this context, mass is analogous to weight and thus can be measured in the same mass units: milligram, gram, kilogram and tonne. For primary school students, the concept of mass can be described as the general "heaviness" of an object. Investigations of mass should foster this concept by

allowing students to heft and compare different objects.

Mass is one of the least common forms of measurement used for comparing objects in everyday situations. The fact that we pay little regard to mass as a way of describing objects is emphasised by the few mass related words there are in the English language e.g. heavy, light, bulk, and massive. Compare these scant descriptive words with the large number of length-related words (e.g. long, short, tall, height, width, depth, thickness, distance, diameter and stride) that we commonly draw on.

One justification for the infrequent use of mass estimation may stem from the differences in our sense of sight and our sense of touch or proprioception. We can use sight to distinguish very small scale length differences between objects that differ by just a few millimetres. However, our aptitude when using the sense of touch to distinguish between two masses is so poor that we are only able to distinguish between the mass of small objects when they are some 100 grams different (Lindsay & Scott, 2005). Thus our perception of mass is far less acute than our visual judgement of length.

19. Tom takes his sports bag to swimming.

The sports bag contains his swimming costume, a towel, a hat, a drink and a tube of sun cream.

Which of these is closest to the mass of the sports bag and its contents?

(A) 5 mg (B) 50 g
(C) 5 kg (D) 50 kg

Figure 1. Mass estimation question for Year 6 (Education Testing Centre, 2003).

Mass — Concepts and misconceptions

Children seemingly have limited experience with estimation of mass and discrimination between objects by hefting. The lack of structured experience may be the grounding for a common misconception held by children in relation to mass. Children recurrently confuse mass with physical size, believing a larger object must be heavier than a smaller one, and similarly, two objects of the same size and shape possess homologous mass (Board of Studies NSW, 2002).

The writers have found few students possess clear ideas about the mass of everyday objects in relation to a standard measurement unit. For example, in a large-scale mathematics competition in which thousands of Year Six students from 9 countries participated, 78% of approximately 30 000 NSW participants and only 55% of around 14 000 participants from Singapore correctly identified 5 kg as the answer for the estimation of mass of a commonly occurring item: a sports bag (Figure 1). This performance level is relatively poor considering the age of the students and the large difference between the mass units given as options.

In contrast, students seem to possess more accurate mental references for the standard measurement of everyday objects with regard to length.

In the 2002 Primary School Mathematics Competition, Year 4 participants were presented with a question on length estimation structurally parallel to the 2003 Year 6 mass estimation previous example. Approximately 90% of 30 000 younger student participants in NSW and 90% of the 11 000 participants from Singapore identified 15 cm as the correct answer (Figure 2).

About how long is a pen?
(A) 15 millimetres
(B) 15 centimetres
(C) 15 metres
(D) 15 kilometres

Figure 2. Length estimation question for Year Four (Education Testing Centre, 2002).

Assessment of length estimation lends itself to pencil-and-paper tests, but assessment of mass is generally a hands-on activity. The innate assessment difficulty for mass estimation may limit the opportunities that students are given to develop the necessary skills.

Importance of estimation

The ability to estimate through the use of a variety of traditional and creative approaches is an important numeracy skill which is useful in everyday situations where measuring devices may not be available or necessary. Thus, it is important that children gain a level of proficiency in the rough comparison of objects of different mass by hefting. The NSW Board of Studies (2002) emphasises the value of children's exposure to estimation activities and notes that accuracy in such tasks is obtained through extensive practice.

Bobis (2004) has suggested that students who are good numerical estimators have a sound knowledge of the basic facts of arithmetic and have the ability to utilise a variety of different strategies when estimating. Students estimating measurement are unlikely to apply a rule learned mindlessly by rote; successful estimation is likely to utilise the application of number sense (Hiebert, 1981, cited in Joram, Subrahmanyam and Gelman, 1998). Thus, estimation has been seen as a direct teaching and learning link to formal measurement which then forms the foundation of other mathematical concepts (Joram, Gabriele, Bertheau, Gelman & Subrahmanyam, 2005).

The following activity is designed to encourage concept formation and higher order cognition in the area of estimation of measurement. It aims to provide students with practical experience in estimation — guiding them to draw links between abstract and concrete — as well as clarifying common mass-related misconceptions held by many students.

Activity

Equipment

- A set of nested eggs. Weight the inside of the eggs using plasticine.
- Balance scales

Figure 3. Eggs weighted with different amounts of plasticine.

What to do

1. Have four eggs on display. Ask a student to tell you an order in which to put the eggs. Discuss why they chose that order; most will do so based on size.

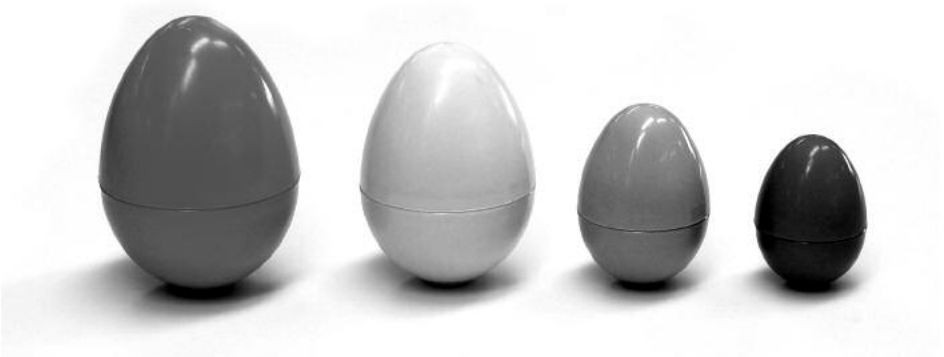

Figure 4. Ordered by physical size: largest to smallest.

2. Ask students whether they can think of other ways to order the eggs (size in reverse, rainbow/light spectrum colours, lightest to darkest tone etc.).
3. Suggest ordering by mass if this does not emerge in class discussion.

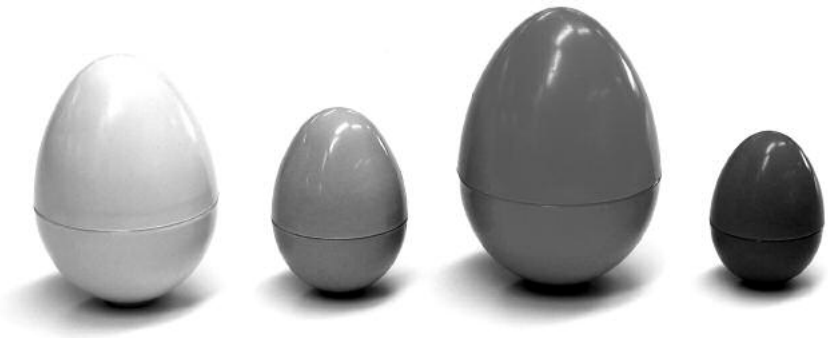

Figure 5. Ordered by colour or tone: lightest to darkest.

4. Ask if they think the order will be the same. Clever students will probably guess what you are up to, so talk about how you cannot tell mass just by looking and ask how it can be worked out. Discuss weighing scales and balances. Remind students of previous occasions using scales.

5. Ask: "What if we don't have scales?". Discuss how one could directly compare two objects.

6. Have students heft two eggs to compare, gradually working out a ranking by mass. Place the eggs in what they think is the correct order.

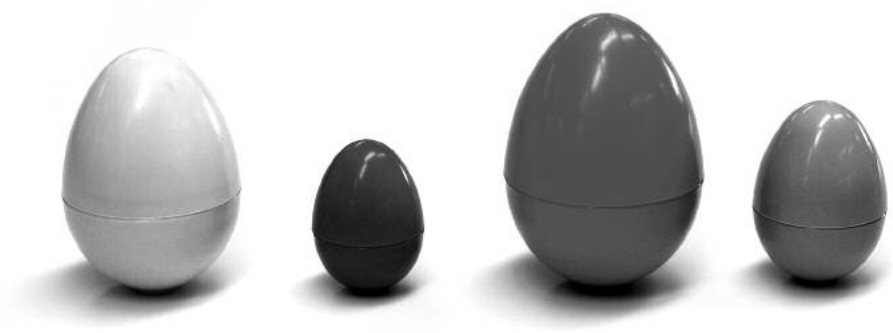

Figure 6. Ordered by mass: heaviest to lightest.

7. Check estimations by weighing the eggs with balance scales.

8. Discuss with the students how easy or difficult it was for them to work out the order of the eggs. Were they surprised by the final order?

Where to from here? "Eggstension" activities for more able students

This simple activity could lead on to investigation of more detailed and formal mass measurement questions such as:

- How accurate do you think your estimation skills are?
- How close in mass do you think two objects would have to be before you could not tell which one was heavier?
- How could your group design a test to find out the "best estimator of mass" in our class?

How learning and understanding of mass concepts can be encouraged and extended with the "Estimating Eggs" activity

- Emphasise concepts rather than methods. Focus on estimating mass rather than the exact measurement. This allows the physical concepts of measurement to be better understood as the students' focus shifts from procedures to processes of

measurement in relation to estimation (Joram et al., 2005)

- Encourage learners to formulate their own ideas. Give students opportunities to explore their own hypotheses within the context of the lesson as they may discover "new" things relating to mass. The session may then be extended by exploring these ideas with the rest of the class. This additional investigation may aid further awareness of relevant concepts.
- Link the Key Learning Areas of Mathematics and Science (Feldhusen, Van Tassel-Baska & Seeley, 1989). The drawing of knowledge from other subject areas such as science can encourage students to approach a problem by utilising their existing knowledge from other fields. This may further encourage students to bring to the activity relevant information in a way which deepens their understanding of the mathematical theories being explored by making it relevant to their own lives.

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Appendix: Relevant outcomes for the "Estimating Eggs" activity taken from the NSW Board of Studies 2002 Mathematics syllabus

- MES1.4.2 describes the mass of an object as being "heavier" or "lighter" than another.
- MS1.4.2 orders the mass of two or more objects by hefting.
- MS2.4.5 measures mass using a given measuring device; e.g., a kitchen scale.
- WMS1.1.7 asks questions related to the size and mass of objects; e.g., "Why is this small wooden block heavier than this empty plastic bottle?"
- WMES1.3.3 uses comparative language to describe; e.g., "I think the pencil is longer than the scissors".
- WMES1.4.5 gives reasons why he/she thinks one object will be longer, taller, wider, bigger, heavier or will hold more, than another.

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